

# Dual Power Generation Using Solar Plus Windmill Generator

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**Abstract**—The growing demand for energy and exhaustion of fossil fuels have greatly emphasized the demand for efficient and environmentally sustainable energy production techniques. Solar and wind energy are pollution-free and plentiful; however, their power production rates highly on weather and atmospheric changes. Solar energy is highly dependent on daylight and weather conditions, whereas the power produced from the winds relies on the speed and changes in the atmosphere. As these energy forms are subjected to high weather dependency, a dual power generating system consisting of both solar and winds has been formulated and designed to produce continuous power. In this system, the solar panel and the wind turbine generator are connected using an uncomplicated charging circuit and diodes to power the battery for energy storage. This energy can be used for the operation of both DC and AC appliances using an inverter device without using advanced power management and automatic source changeover techniques. The system is equipped with an Arduino-UNO based monitoring system for observing voltage and current parameters through sensors and an LCD device in real-time situations.

**Index Terms**—Dual power generation, solar energy, wind energy, hybrid renewable energy system, battery storage, Arduino monitoring.

## I. INTRODUCTION

Energy is one of the basic necessities for the growth of modern civilization. It is used for the generation of power for the purpose of domestic, industrial, agricultural, and communication use. The population growth, development of the industrial sectors, and the development of technology have resulted in the enhancement of the use of energy. The power production technologies used by the generation

companies are based on the use of fossil fuels. The fossil fuels are known to cause environment pollution. Increasing environmental issues, fuel prices, and exhaustibility of fossil fuels have brought about greater development in the shift to the usage of other energy resources. Renewable energy resource solutions are clean, eco-friendly, and feasible alternatives. Amongst all other alternatives, solar energy and wind energy are popular energy choices owing to their widespread availability and development. Solar energy converts sunrays into energy through photovoltaic cells, whereas wind energy converts wind energy into power through turbines.

But when considering these power sources individually, solar as well as wind energy can pose some limitations because they are intermittent power sources, as solar power depends upon sunlight and wind, which changes with atmospheric factors, and wind power depends upon wind, which changes with wind speed as well as atmospheric factors. To tackle these difficulties, hybrid renewable energy systems are designed by combining two or more energy sources simultaneously, thereby improving reliability.

The manuscript proposes a combined power generation system utilizing solar power and wind energy by implementing a simplistic charge controller, a diode protection method, and energy storage within a battery system.

The proposed system also omits sophisticated control algorithms, which further reduces cost and complexity of design. An Arduino UNO-based system is designed to monitor the system voltage, which further provides energy from the storage system to the DC & AC loads via an inverter.

## II. LITERATURE REVIEW

Substantial research has also been done in the area of renewable energy systems, with efforts directed at improving the efficiency, reliability, and sustainability of power production. Hybrid systems combining solar and wind energy can be considered among the areas that have received a lot of attention, as they tackle the intermittency problem of stand-alone renewable energy.

Kirubhakaran et al. [1] proposed a hybrid power generation system based on solar and wind energy for residential use. The system combined solar panels and a wind turbine by using MPPT controllers and Buck Boost Converters. Although this method enhances the efficiency of the solar system and ensures a continuous supply of power, the system is complex due to the implementation of advanced controllers and power electronic circuits, which makes it less appropriate for cost-effective and smaller-scale systems.

A hybrid solar and wind power system for domestic consumption has been designed by Prashanth et al., [2] which utilizes photovoltaic cells, a horizontal-axis wind turbine, batteries, and an inverter for providing AC power. Experiments carried out on the system proved it to be more reliable than standalone systems. But the fact that it demands larger systems and installation costs made it less feasible for low-cost and small-scale applications.

A portable dual power generation system, involving solar panels and a windmill generator, was proposed by Bakare et al. [3] to provide both reverse current protection using diodes and the facility to recharge batteries from both systems. Even though this system is capable of continuous power delivery, it concentrated on being portable and of higher capacity, making it bigger and expensive.

A solar-wind hybrid system based on microcontroller monitoring and charge regulation was put forward by Ismail et al. [4] The design used lead-acid batteries and maximized the efficiency of the wind turbines even at low wind speeds. While efficiency has been improved through better usage of energy, the system has become more complex and expensive.

A number of research works have also been carried out on MPPT-based hybrid solar and wind systems for increasing the efficiency of power harvesting. These hybrid systems are complex because they require complex algorithm-based controlling and sensing and

power electronics circuits, and are generally restricted to simulations on a larger scale. The literature survey reveals there is less focus on low-cost and hardware-based design with simple controlling techniques. Therefore, there is a need for a low-cost and easily implementable dual power generation method.

## III. PROPOSED METHODOLOGY

The proposed method targets the development of an efficient and cost-effective hybrid power generation system that combines solar and wind energy sources. Unlike traditional self-reliant power-generation systems that involve individual solar panel and wind turbine energy conversions, the hybrid system combines both sources to provide an accumulated renewable energy output that is stored in the battery, the block diagram of the proposed dual power generation using solar plus windmill generator is shown in Fig. 1.

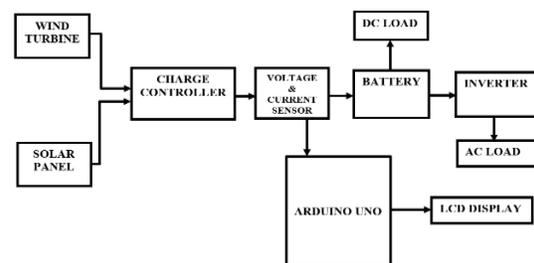


Fig. 1 Dual power generation using solar plus windmill generator

### A. Solar Energy Generation

The solar energy subsystem comprises a solar panel referred to as a photovoltaic (PV) solar panel. The solar panel directly converts sunlight to DC electrical energy based on the photovoltaic effect. The interaction of sunlight with solar cells leads to the generation of electrical energy as a result of the movement of highly excited free electrons. The solar panel produces differing voltages and powers depending on the intensity of sunlight. In the proposed design, the solar panel will act as a major energy source throughout the day.

### B. Wind Energy Generation

The wind energy plant uses the kinetic energy available in the blowing wind to produce electricity

through the use of a windmill electrical generator, which operates through electromagnetic induction. The rotary motion generated by the passing wind is used to convert the energy into electricity. The amount of generated power is dependent upon the speed of the wind and the revolving speed. The hybrid plant will complement the solar plant when there is limited sunlight, for example, when it is cloudy, in the evening, and at night.

The DC geared motor is used in place of a wind generator to realize low-speed power production, economy, as well as safe demonstration. The gear system facilitates the production of energy even during low-speed rotation. Running in either natural wind or artificial wind current, the DC motor acts as a generator capable of generating DC power in levels dependent on the rotational speed. The generated power is then delivered to the charge controller and battery setup to merge with solar power for stable function.

#### C. Charge controller

The charge controller is an important part of the dual power generation system which is responsible for regulating the combined electrical output from the solar panel and wind generator. The device will ensure that the battery is charged safely and without risks of overcharging, deep discharging, or sudden voltage spikes. To provide additional protection to the system, the use of diode is employed at the end of the output of the charge controller to ensure that the battery cannot power the solar panel or wind turbine when power generation is at low levels. The inclusion of diode in the system ensures greater protection against power loss and guarantees a longer life for the battery to perform its operation of providing power to the loads efficiently.

#### D. Battery storage system

The battery will act as the energy storage unit of the system. It will store excess energy generated from solar and wind sources and supply power during periods of low or no generation. In the proposed system, battery is used to obtain a suitable DC voltage for the operation of the load. The energy storage system enhances power continuity and reliability, especially for off-grid and remote applications.

#### E. Arduino UNO Monitoring

The Arduino Uno interprets the voltage information obtained from the voltage and current sensor through the usage of programmed logic, and the actual value of the voltage is calculated. The processed data corresponds to the real-time output voltage of the charge controller. Lastly, the processed voltage data is transmitted to the LCD display, where the value will be clearly visible. This will enable the user to easily monitor the charge controller voltage.

#### F. Load Supply

The DC power from the battery can be directly given to the DC loads, thereby reducing conversion losses to a great extent. The inverter acts as a means of transforming the DC power into AC power in order to drive the AC loads, such as light bulbs and small appliances.

There are some fundamental elements to the whole architecture:

##### 1. SOLAR PANEL



Fig 2. Solar panel

The solar panel used in this project is typically a 12V panel with a power rating of 20W, which produces around 1.6 – 1.7A of current during full-noon.

##### 2. Charge Controller



Fig 3. Charge controller

The hybrid charge controller in this project accepts a DC input from the solar panel and DC output

generated by the geared motor acting as a wind turbine. It operates an input voltage range of 6 – 24 V and provides a regulated DC output.

### 3. Silicon rectifier diode (IN4007)



Fig 4. Silicon Rectifier Diode (IN4007)

Used for back-flow protection in the circuit. It protects the controller and battery from accidental wrong connections and sudden voltage spikes, improving system safety and reliability.

### 4. ARDUINO UNO

Act as the main controller of the system. It monitors voltage and controls the load (fan, LEDs, display), manages power flow, and automates the working of the hybrid solar-wind system.



Fig 5. Arduino uno

### 5. Lithium ion battery



Fig 6. Lithium ion battery

These lithium-ion cells store energy generated by the solar panel and windmill. They provide 12 V to the system and power supply backup power when

renewable sources are unavailable, ensuring continuous and reliable output.

### 6. LCD Display (16×2)



Fig 7: LCD Display (16×2)

Alphanumeric LCD display operating at 5 V voltage. It has I2C interface, displays system status such as voltage.

### 7. Inverter

Converts DC power from the battery into 230 V AC, allowing AC loads to run using energy from the solar panel and wind turbine in the hybrid system.



Fig 8. Inverter

### 8. Gear Motor



Fig 9. Gear Motor

The DC geared motor is used as a wind turbine generator substitute to demonstrate wind energy generation in the dual power generation system. When the shaft is rotated, it operates in generator mode and produces DC power, which is supplied to the charge controller for battery charging.

9. Current & voltage sensor



Fig 10. Current & voltage sensor

The INA219 sensor module is used to measure real-time voltage and current flowing from the solar panel, wind generator, or battery to the load. It enables accurate calculation of power and energy consumption, which is displayed on LCD through the Arduino UNO. This sensor plays a key role in system monitoring, helping analyze performance and battery charging behavior in the dual power generation.

IV. RESULTS & DISCUSSION

The proposed solar-wind hybrid power generation system was implemented and tested under real-time conditions to validate its performance and reliability. The system was analyzed based on power generation, charging the battery and supply to the load concerning environmental condition variations.



Fig 11. Overall experimental setup

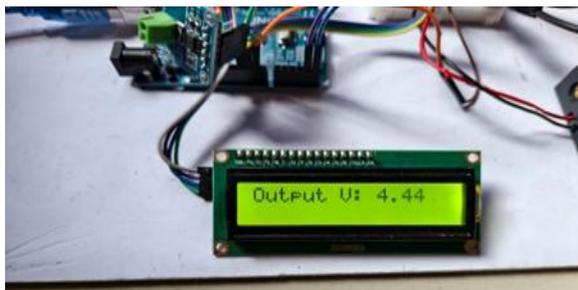


Fig 12. LCD showing Dc regulated output voltage

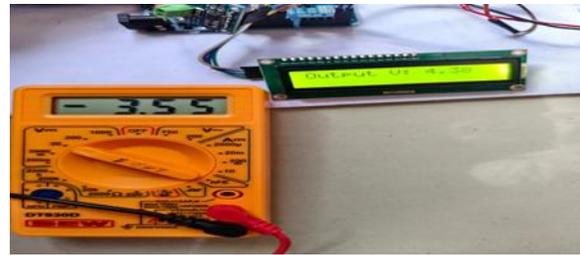


Fig 13 Output voltage measurement using multi-meter



Fig 14 DC load powered using battery



Fig 15.AC load powered through inverter(charging)

Fig 2 to 6. shows the experimental results for the design of the hybrid solar-wind power generation system.

Fig 2. Shows the prototype experimental setup of the hybrid system. It consists of a solar panel, gear motor ,battery, charge controller, Arduino-based control unit, voltage and current sensors, and LCD display, all components are interconnected through appropriate wiring. This experimental setup is used to monitor real-time power generation and regulated charge controller output voltage under varying environmental conditions.

Fig 3. Shows the regulated DC output voltage displayed on the LCD which is interfaced with the Arduino uno, showing an output voltage in the range of approximately 4.0-4.3V. This ensures that the charge controller regulating the input voltage from both the solar panel and wind turbine produces a DC voltage for charging a battery, suitable for a DC load operation.

Fig 4. Illustrates the measurements of the output voltage by a digital multi-meter, and the reading obtained has closely matched the LCD reading, thereby validating the accuracy and reliability of the voltage sensing and monitoring circuitry.

Fig 5. Presents the operation of a DC load powered directly from the battery, which confirms the stored energy from the hybrid system can be effectively used for DC applications without using additional voltage regulation.

Fig 6. Depicts the operation of an AC load through an inverter, where charging a mobile phone through AC power obtained from a battery, thus validating the capability of the system to provide both DC and AC loads, thereby emphasizing the flexibility of the proposed hybrid power generation system.

**A. Result Analysis**

1. Solar power generation analysis: The solar panel subjected to varying light intensities of the sun. At full noon, the maximum voltage produced by the panel was 18V with a current of 1.2 A, yielding a power of about 21.6 W.

2. Wind power generation analysis: The wind energy subsystem, implemented using a DC geared motor to demonstrate wind power generation, the maximum voltage generated was 5V with a current output of 0.3a, resulting in a power output of approximately 1.5W.

3. Battery charging analysis: The battery is charged through the charge controller using power obtained from both solar and wind energy sources. The observed charging voltage is ranged between 12 V and 14 V, while the charging current varied from 1A to 1.2 A under maximum solar conditions and increased slightly with the contribution from wind energy.

Table I : Electrical Performance of Solar and Wind Sources (5 Hours)

Source	Condition	V(V)	I(A)	P(W)
Solar	Noon sun	18	1.2	21.6
Solar	Cloudy sun	16	0.8	12.8
Wind	Moderate	5	0.4	2.0
Wind	Low	3	0.2	0.6

**B. Performance Analysis**

Table II: Operating Characteristics Of Power Generation

Module	Output range
Solar power generation	18 – 20 V up to 1.2 A
Wind power generation	3 – 5 V , 0.3 to 0.5 A
Combined power output	Continuous supply

Maximum power was recorded during full noon sunlight exposure, while lower power was experienced during cloud cover. Depending on the wind speeds the output of the wind power is varied. The integration of the solar and wind power sources ensured uninterrupted power supply.

Table III: Battery Charging And System Stability Analysis

Parameter	Status
Battery charging	Stable
Charging method	Diode – based
Reverse current protection	Enabled

Smooth and stable battery charging was observed using a basic charge controller with diode – based source based isolation. The diodes effectively prevented reverse current flow, ensuring stable system operation under different solar and wind conditions.

**V. CONCLUSION**

This paper presented a dual power generation system using solar and wind energy to ensure reliable and continuous power supply. The proposed system integrates a photovoltaic solar panel and a windmill generator through a charge controller with diode protection to safely charge a battery and supply both DC and AC loads. An Arduino UNO based monitoring unit enabled real-time voltage observation. Experimental results confirmed effective voltage regulation, accurate monitoring, and uninterrupted power availability. The system offers a low-cost, simple, and scalable solution for small-scale, off-grid, and rural renewable energy applications.

**VI. FUTURE SCOPE**

The proposed dual power generation system can be further enhanced by integration of IoT-based remote monitoring will facilitate real-time observation of

voltage, current, power output, battery status, and overall system health. Further, sensor data can also be transmitted to the cloud platform using onboard Wi-Fi or GSM modules that allow performance monitoring through mobile or web applications, facilitating early detection of faults and efficient maintenance.

Future work may also include the implementation of intelligent source management along with MPPT charge controllers further enhances system efficiency. The MPPT adjusts operating voltage and current continuously in order to track the maximum power output from solar and wind sources under varying conditions. Automatic source switching can be added to select the most suitable energy source.

For industrial and commercial purposes, the system can be scaled up by integrating larger solar arrays, high-capacity wind turbines, and advanced inverters with robust control units. This hybrid setup will be more capable of reducing the dependency on the grid, lowering the energy cost in operation, and supporting higher power demand upon integration with energy management systems and intelligent load distribution. Long-term system performance could also be improved by incorporating energy forecasting and intelligent load management techniques. By analyzing the historical data of solar irradiance, wind patterns, and power consumption, energy availability can be predicted by the system and schedule the loads accordingly.

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